Cartographic generalization and specificities of geographical domain in Algeria

Abdelghani KADDOUR DJEBBAR

National Institute of Cartography and Remote Sensing

E-Mail: inct99@wissal.dz contact@inct.dz

Abstract: saving both time and cost of map production has always been a concern for cartographic professionals. One of ways to do, is "to generalize", which consists in extracting from a reference map, information for a particular need and simplify their representation: a new generalized map is then ready for exploitation . However, there is a disadvantage for this technique, for it is carried out manually. Recently, the development of digital cartography, in origin of the automation of geographic data treatment has given birth to the automatic generalization.

This work joins a research axe and it is interested specifically on cartographic generalization. This latter has been the object of a lot of researches which have been studied in order to solve a big complex number of problems and this, in the objective to define a process which contains every operator able to take charge of a sequence of many generalization program, oriented by a specific parameterizing and this, in a predefine execution order.

Key Words: Process, automatic generalization, operator, conflict, enrichment.

1. Introduction:

Cartography is a plane and conventional representation of a part or the whole of geographic space. Generalization is the selection and simplification of this space according to the scale and the map objectives.

Many are problems and conflicts that occur when changing the representation scale. A local conflict mainly related to the limits of human perception, hence the need to define thresholds of perception according to

the representation scale. Global conflicts are defined as part of a contextual global generalization, including the impact of a local generalization of an object in its neighborhood.

To remedy at these conflicts and in order to implement an automatic and open generalization process according to the objectives to be attained, the INCT provided since few years, efforts resulted in an ambitious program through partnership with the universities and research institutions, but also through a quality training, which this work is part. The objective is the establishment of a cartographic generalization process, automatic and customizable, and its integration into the INCT mapping production line.

The cover of the Algerian territory with topographic maps at various scales is considered to be very expensive and a slow process, thus in comparison with the large surface of the country and the means granted for this mission. The goal through this study is to automate a part of the line production and produce a new cartographic cover at 1/200 000 with the lower costs and within reasonable time.

2. Objectives:

This study concerns an entire data set and not a specific theme. We consider a contextual generalization: "*When we modify an object, it is the entire space that is impacted*" [Ruas 99]. The technical difficulty of automating the generalization process comes from choosing the right procedures to be applied: where? in what order? on which objects? [Brassel & Weibel, 1988; McMaster & Shea, 1989; McMaster & Shea 1998]. The objective in a research and industrial optic is to produce, from geographic data at 1/50 000 a map at 1/200 000 through a contextual generalization process to be implemented. This process is based on a sequence of treatment operators (programs) applied to objects in a well defined order [Müller et al 93; Reg 98] aimed to provide a better generalization and handle any type of conflict while respecting the forms, relationships, semantics and overall harmony of geographical space.

3. Process:

A generalization process aims to generalize an object or set of objects by application of generalization algorithms based on the execution order, the objectives set, the expected product quality and values (thresholds) chosen by empirical methods.

The first generalization process was defined in early 1990's (Monmonier, 1991; Müller & Wang, 1992; Schyllberg 1992; Tallis & Mackaness, 1996; Peng & Al, 1995, etc..) and involved only a few geographical themes. Since that, many generalization processes, more generic and applicable to various themes, have been proposed. Thus, more automatic generalization methods are used by many cartographic entities (Le Men 1996 Lemarié 2003 Lecordix et al. 1997 and 2007; Touya 2007, Revell 2004 Revell et al. 2005 Regnauld 2007 Regnauld et al. 2007, and Pla Baella 2003, etc..).

The cartographic generalization process we propose is based both on modeling the original database (1/50, 000) reshaped to match the process results (database 1/200 000), and on the data dictionary used at INCT.

"*The process starts from the needs expressed by the user until the generalized data*" [Ruas 99].

The cartographic generalization process proposed involves three main steps as shown in the following diagram:

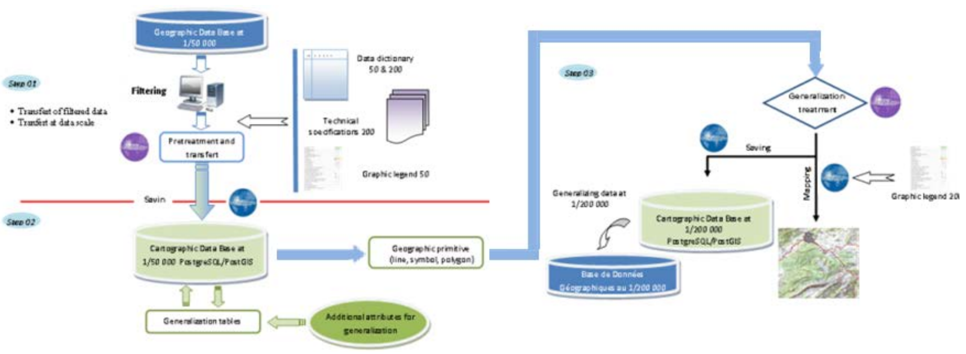

Figure 1: The adopted process for generalization 50k - 200k

The first step, as its name indicates it, is to recover geographic data of a data set at 1/50 000 (15'x15 ') equivalent to a sheet at 1/200 000 (1 ° x1 °). These data will undergo a filtering and geometric preprocessing such as filtering points, preliminary smoothing or connecting road segments. The data filtered and preprocessed are stored in a PostgreSQL database.

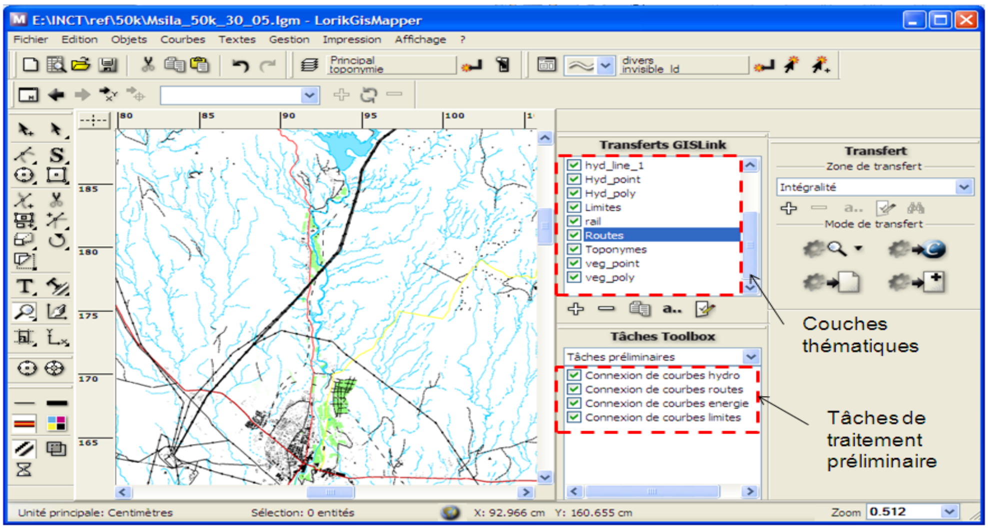

Figure 2: GIS data at 1:50 000, transfer interface

The second step is to add as many additional attributes as needed in the attribute tables of each object under generalization (Figure 3). These attributes will act as triggers, under conditions of different generalization treatment programs. A stretch of road, for example, may have additional attributes as an attribute "filter" attribute "smoothing" attribute "conflict treatment", etc.. The two tables below show the additional attributes that we propose to enrich the attribute tables for linear and surfaced objects:

	Additional attributes		
	Filtering	**Smoothing**	**Conflict treatment**
Lines	Conservation	Point proche	Faille max (auto conflict, pasting of isolated
	Suppression	Douglas_peucker	Faille min (pasting of non-isolated turns)
		Gaussian	Displacement with priority (inter conflict, intra conflict)
			Accordion (pasting of series of turns)

Table 1: Additional attributes: case of lines

Attribute "**filtering**": a section of line is conserved or deleted (size, importance)
Attribute "**smoothing**": a section of line is smoothed by a three (03) algorithms (the choice of treatment depends on the purpose and desired quality)
Attribute "**conflict treatment**": a line segment may undergo, as appropriate, one of the four (04) treatments.

	Additional attributes		
	Filtering	**Smoothing**	**Conflict treatment**
Polygons	Conservation	Smoothing of the thrust	Displacement with priority
	Suppression		Amplification
			Aggregation

Table 2: Attributes Additional attributes: case of polygons

Attribute "**filtering**": a polygon is conserved or deleted (size, importance)
Attribute "**smoothing**": small polygon thrusts can be smoothed by defining a threshold length / width ratio
Attribute "**conflict treatment**": a polygon may undergo, as appropriate, one of the three (03) treatments.

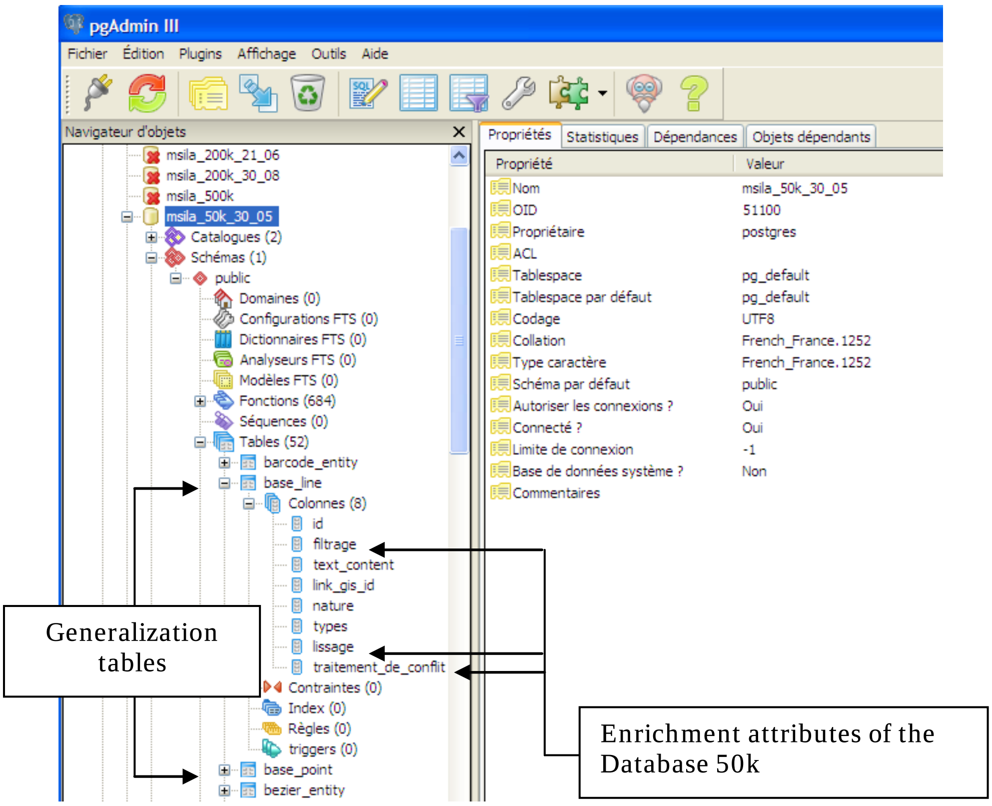

Figure 3: Adding additional attributes in the tables of PostGres database

4. Generalization operators (programs):

It is essential to include all cases of conflict that may be encountered during the generalization operation, and propose for each case, one or more treatments as additional attribute values (the settings of each program depends on the use, the precision and the representation scale) to apply simultaneously to get a better result while preserving the quality, completeness and overall harmony of the map.

Values for each additional attribute are operators (Figure 4) to be applied to objects, to generalize. The system starts automatically the treatment for each attribute value.

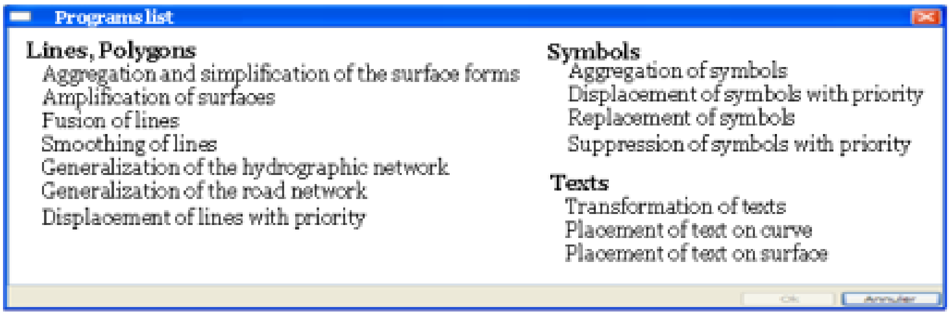

Figure 4: generalization programs in the adopted process

5. Conflicts:

Are presented below some examples of conflicts encountered when changing the representation scale:

5.1. Superposition (overlapping) of two linear objects of different nature

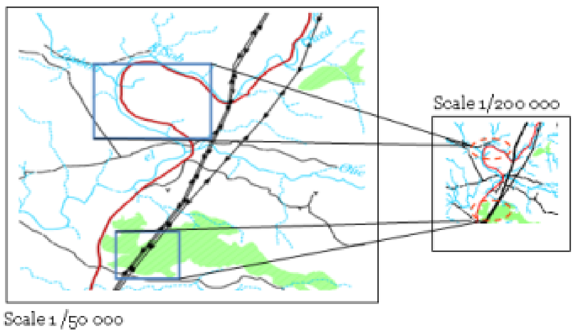

Figure 5 : Not-separation of the very close objets

In this figure, the two conflicts are identified. The first leads to a difficulty in distinguishing between the road and the flow of water, having a distance, between them, under the threshold of visibility. This threshold makes it impossible to know for the second conflict if it is one or many power lines. A displacement treatment of the road for the first case and a lines fusion for the second case should be performed to deal with these conflicts.

5.2. High density buildings in an urban

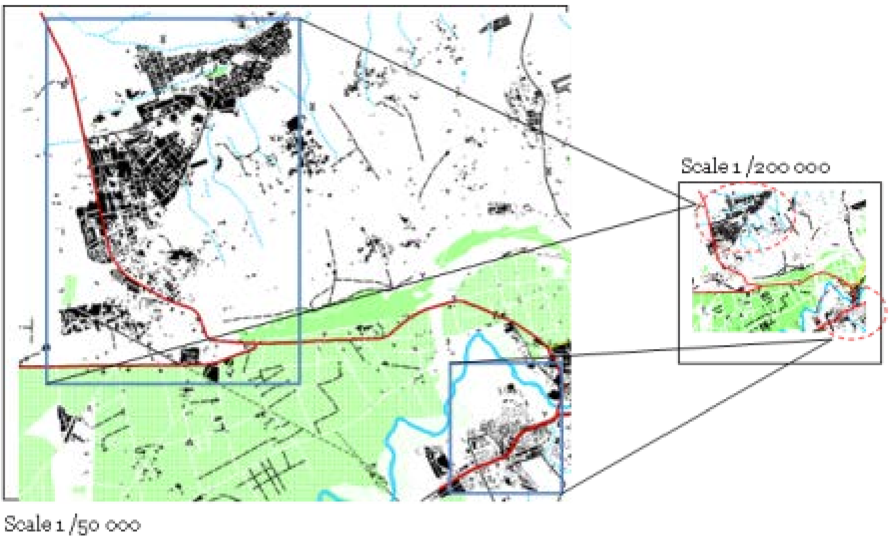

Figure 6: High density in agglomerations

Agglomerations at scale 1/200 000 have a non-perception and a non-distinguish conflict between constructions of high density. That conflict does not occur at scale 1/50 000 since the objects were compiled at the representation scale. To overcome this issue, an aggregation treatment of constructions should be applied.

5.3. Pasting of isolated turns

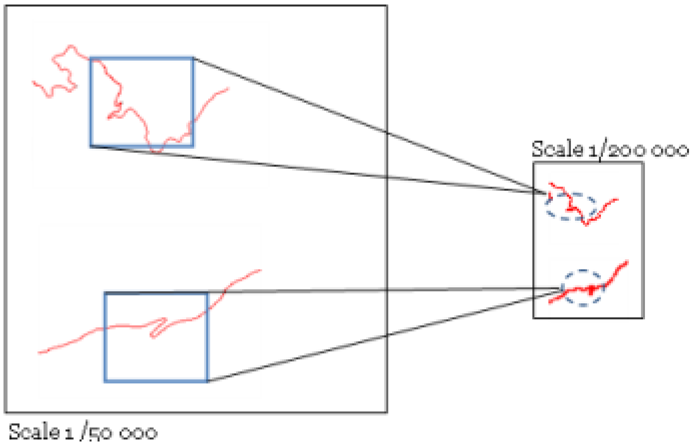

Figure 7 : Pasting of isolated turns

In these two examples (Figure 7), we see clearly that the isolated turn form is not identifiable at 1/200 000, unlike its appearance at 1/50 000. The solution is to separate these turns while maintaining the overall form of the road.

5.4. Pasting of series of turns

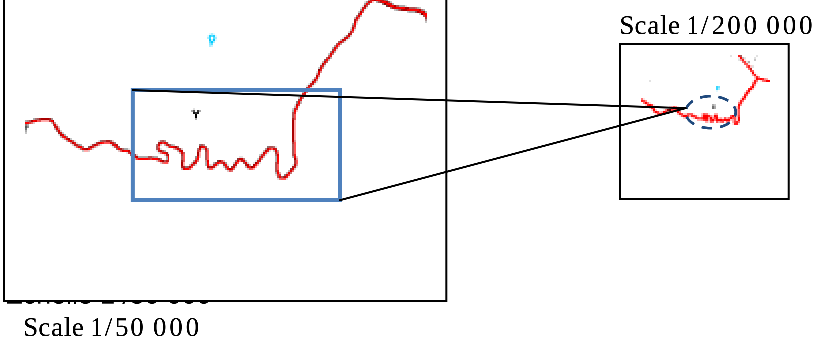

Figure 8 : Pasting of series of turns

The form of a series of turns (Figure 8) is not as readable at 1/200 000 scale as at 1/50 000 scale.

6. Conflicts treatment:

Process and generalization operators (programs) will handle any type of conflict occurring when changing the representation scale. The process consists in *linking* these operators in a *specific order* according to a static model [Müller & Wang 91, Reg 98] and with a *specific parametrizing* required (north zone, south zone, the use of the product ...).

"*The presence of cartographic conflicts constitutes conditions that should trigger generalization treatment. These conflicts must be detected through measurements. To find out which algorithm is then appropriate to resolve a conflict and with what parameter values, we must have previously studied algorithms that are available to determine their applicability: "Once candidate algorithms exist, They shoulds be Assessed in terms of Their Applicability to specific generalization requirements* " [Shea and McMaster 1989, p.61]. "[Duchene, 2004 p30].

A sequence of operators:

"*Tests of using existing algorithms demonstrate the need to chain many algorithms to achieve a satisfactory generalization*" [Ruas, 98b; Regnauld, Edwardes and Barrault 99; Mustière 2001].

An execution order:

"*The approach is systematic predefined sequence preset fixed sequences of algorithms to trigger for each class of objects. The algorithms are then applied automatically one after the other to objects of each class. In this approach, the applied algorithms take only into account the type of objects and possibly some of their attribute value*" [Mustière 2001].

[Regnauld, 98] proposes the following sequence, which applies to constructions:

- Displacement (in relation to road)
- Selection and expansion
- Simplification of contours
- Merge of constructions
- Further simplification of contours

.... And at INCT

A list of operators is defined in the generalization process. There are based on a predefined sequence, and can chain several treatments that apply to one or more objects.

For line:

- filtering: preserving or deleting objects by nature / size;

- smoothing: deleting points to relieve the line from the restitution; deleting points by comparison (point_proche) Douglas & Peuker;

- displacement with priority - Delaunay triangulation;

- merge lines close of the same nature (replacement by a median line);

- separate isolated turns (hybrid);

For surface:

- filtering: preserving or deleting objects by nature / size);

- displacement of constructions (In overlapping with linear) - Delaunay triangulation;

- aggregation by filling - Delaunay triangulation;

- smoothing: simplification of contours (hybrid);

- smoothing: Remove peaks;

- amplification of isolated surfaces, below the perception (buffer).

For point:

- filtering: preserving or deleting objects by nature;

- displacement with priority-Delaunay triangulation;

- aggregation by displacement / replacement;

A specific parametrizing:

The empirical method we have adopted in our work shows the dependence of the choice values (thresholds) used for cartographic needs and objectives of the process in place. In fact, the manufacturer of the map, as a cartographer, can judge the result of generalization according to his expectations, and can comment on the limits of the latter.

Going to this principle, and following a series of generalization tests, our treatment thresholds have been set and always compared to our expectations and needs.

7. An example of parameterized operators:

All generalization programs (operators) integrated into our processes have been defined on the basis of known algorithms in the generalization

universe. Adapted to the needs of production and enriched by mapping specific solutions, these algorithms were coded in C + + computer language, in partnership with Lorienne-France, developer of mapping solutions. We present herein some examples of these operators:

Aggregation of areas (high density conflict):

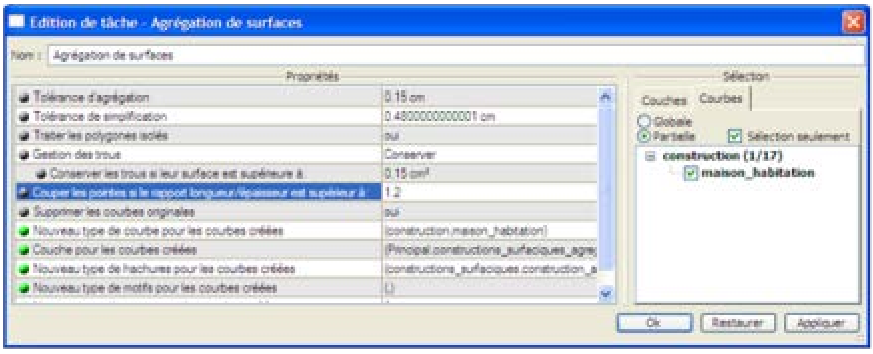

Figure 9: parameter setting interface of operator “Aggregation of surface”

Aggregation tolerance: value that defines the research tolerance to determine which polygons should be aggregated (those who are far away from a value below the tolerance);

Simplification tolerance: value that defines the simplification tolerance of the resulting polygons ;

Treatment of isolated polygons: isolated polygons behavior: the polygons that are not aggregated (a value of separation distance superior to the tolerance of aggregation);

Management holes: behavior of holes

Cut the tips if the length / thickness ratio is higher than: The tips will be cut if the ratio between the length of the tip and its thickness is greater than the value entered.

Points Aggregation (conflict density):

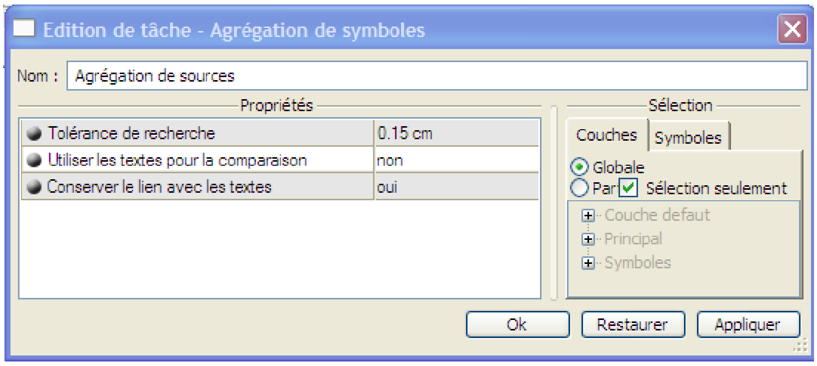

Figure 10 : configuration interface of the operator "Aggregation of point objects »

Research tolerance: When two or more identical symbols are placed at a distance less than this value, these symbols are aggregated and then replaced by one. The research tolerance is calculated from the insertion point of the symbol.

Use texts for comparison: If this parameter is set to "yes", it is the value of text associated with each symbol that will determine if the symbols must be aggregated or not: if the texts are different, symbols are not aggregated.

If this parameter is set to "no", the symbols are aggregated in all cases, since they are contained within the tolerance.

Maintain the link with the text: If this parameter is set to "yes", identical text will be replaced by the same one. If this parameter is set to "no", the existing texts conserve their original position.

Close Lines Fusion (non-separation conflict):

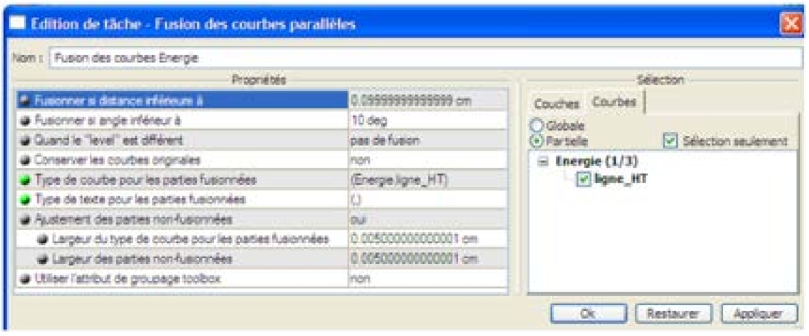

Figure 11: configuration interface of the operator “Fusion of parallel lines “

Merge if distance less than: Maximum distance to consider two parallel lines as to give rise to an average line.

Merge if angle less than: Limit angle to consider two segments as non-parallel. Beyond this angle, lines can not be merged for the corresponding portion.

Amplification of surfaces (small areas):

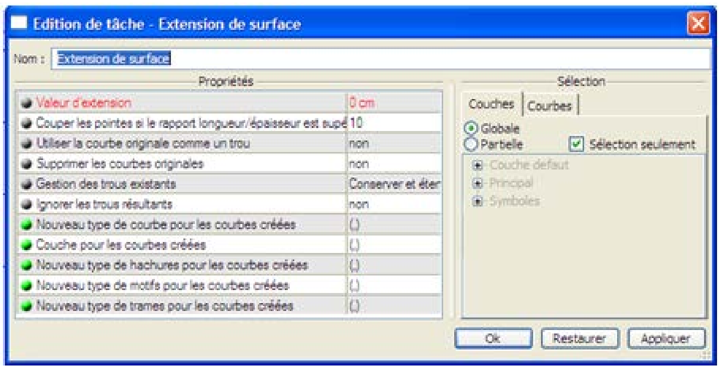

Figure 12 : configuration interface of the operator « Amplification of surfaces »

Extension value: value that defines the width of the buffer outside the original surface.

Cut the tips if the length / thickness ratio is higher than: The tips will be cut if the ratio between the length of the tip and its thickness is greater than the value entered.

Lines Smoothing:

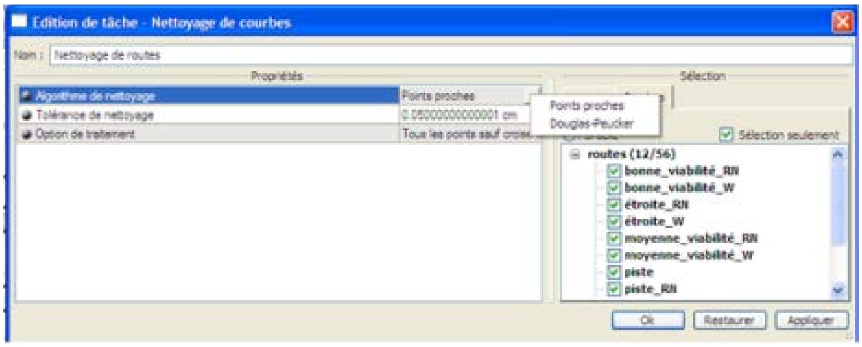

Figure 13 : configuration interface of the operator « Smoothing lines »

Cleaning tolerance (smoothing): This parameter has a different concept depending on the algorithm chosen.

Treatment option: Allows you to define exceptions to cut points

8. Operators - Results of treatment:

Are listed below, generalization operators (see the third step - conflict treatment) in execution order in the process.

Linear filtering and connection of linear segments
Smoothing of linear objects
Displacement linear objects with priority
Merge of close lines (or parallel)
Separate isolated turns and series of turns

Displacement of construction (above linear)
Aggregation of construction by filling (with smoothing contours and suppression of tips)
Amplification (buffers) or replacement of isolated surfaces with punctual symbols.

Displacement of punctual objects with priority
Aggregation of punctual objects with displacement
Suppression of punctual objects with priority

Placement of text (on lines, flat, on surfaces)

Conflicts and sequencing treatment results above are presented in Figures 14 and 15.

9. Results of treatment:

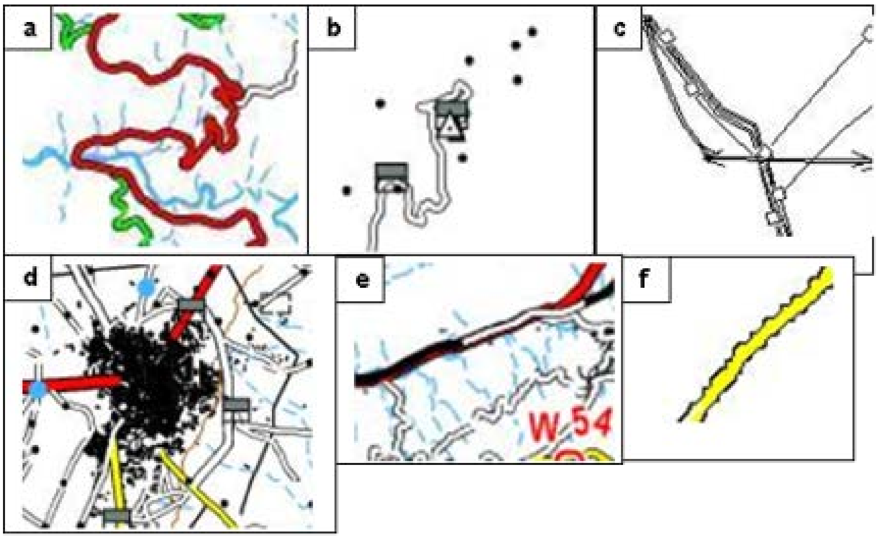

Figure 14 : some extracts from a map at 1: 200 000, before generalization

(**a**) : pasting of series of turns ; (**b**) : superposition of punctual objects having different nature; (**c**) : no separation between lines ; (**d**) : high density of constructions; (**e**) : superposition of linear objects having different nature; (**f**) : sinuosity of lines

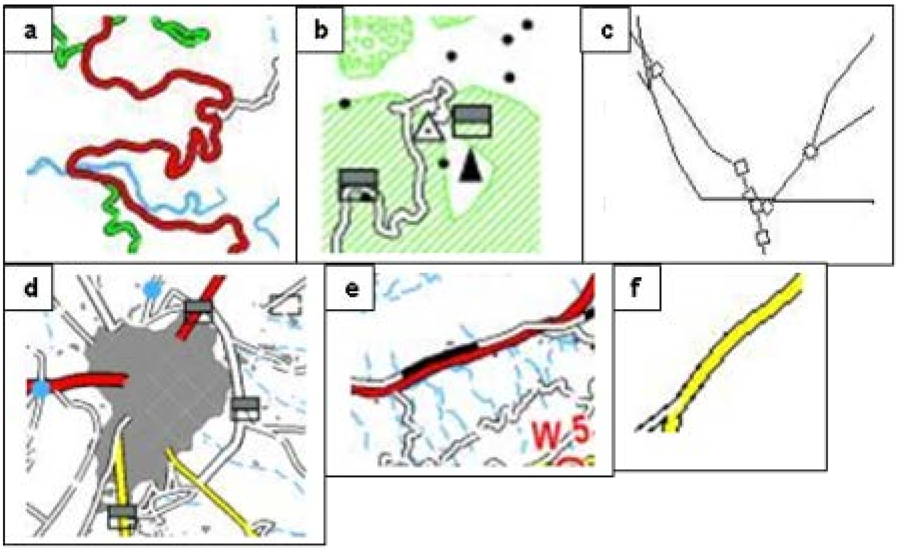

Figure 15 : some extracts from a map at 1: 200 000, after generalization

(a) : separate isolated turns (solution based on triangles treatment) ;
(b) : displacement of symbols with priority (triangulation of Delaunay) ;
(c) : merge power lines HT (creation of median line);
(d) : Aggregation of construction (triangulation of Delaunay – aggregation with filling) ;
(**e**) : displacement of linear with priority (triangulation of Delaunay);
(**f**) : smoothing of linear (point_proche).

10. Evaluation of results:

"*The difficulty of automating the generalization is not only in the design of algorithms for processing, but in the analysis and information of criteria to understand and identify the informative value of objects*" [Ruas 2002].

According to [Bard 2004]: "*A good generalization is a generalization of quality*." This definition leads us to define quality for better understanding.

[ISO 94] define it as the "*totality of features and characteristics of a product or service which gives the ability to satisfy expressed or implied needs." From there, it is essential to fix the specifications (document specifies the requirements which the product must comply) and evaluate thereafter, the conformity of the product to its specification.* "

There are many approaches for quality control which have been defined and proposed such as the approach Ehrliholzer 1995 or that of Harrie 2001. However, and away from these approaches and quantitative assessments (in general, they are based on choice of a violation constraints degree, or acting trigger of a bad generalization alert), we have chosen to evaluate the results of our generalization as follows:

• Visual control: the cartographer applies a visual evaluation by comparing the result of generalization at 1/200 000 to the initial data at 1/50 000, and thus, for a quantitative control;

• A control based on reference data: regarding technical specification of the destination scale (after generalization), visibility constraints, preservation, and thresholds of validation or rejection.

11. Conclusion:

This study focused on the principle of contextual generalization. We found that the use of several operators in a single generalization algorithm improves the efficiency of cartographic generalization. However, this plurality is not sufficient because the execution order of these operators affects directly the treatment results. Our tests have shown that it is essential to reorder treatment operators, where treatments to be applied are

function of: the relief, the spatial distribution of geographical objects and intended outcome of the treatments.

The process we have developed allows at any time cartographer, to reorder treatments and change the setting of each of them (open system).

We brought a piece needed to build a cartographic generalization system, operational and easily integrated into the mapping production process at INCT, although it solves only a small part of the problems encountered in the field of generalization as a whole.

The automation of cartographic generalization is one of the main research challenges in the field of automatic mapping. This study shows the difficulty of automation, because it is difficult to imitate an approach sometimes subjective and intuitive. This explains why nowadays, no GIS software has been able to effectively cover all the problems of generalization in a full automated way.

12. References:

[BARD 04] S. Bard, 2004 : Méthode d'évaluation de la qualité de données géographiques généralisées : Application aux données urbaines

[CORINNE 96] P. Corrine, 1996 : Enrichissement des bases de données géographiques : analyse de la géométrie des objets linéaires pour la généralisation cartographiques (application aux routes). Thèse de doctorat, Paris 1996.

[DUCHÊNE 01] C. Duchêne, 2001 **:** Road generalisation using agents, in Proceedings of the 9thGISRUK Conference, Glamoran (Pays de Galles), laboratoire COGIT, IGN-SR 01-001/S-COM-CD, 2001.

[FRITSCH 97] E. Fritsch, 1997 : Représentations de la géométrie et des contraintes cartographiques pour la généralisation du linéaire routier, thèse de Doctorat de l'Université de Marne-la-Vallée, spécialité : Sciences de l'Information Géographique, soutenue le 12 décembre 1997, laboratoire COGIT, IGN-SR 970008/S-THE, 1997.

http://recherche.ign.fr/labos/cogit/pdf/THESES/FRITSCH/These_Fritsch_1997.zip

[GAFFURI 08] J. Gaffuri, 2008 : Généralisation automatique à base d'opérations discrètes et continues pour la prise en compte des thèmes champ : le modèle GAEL, Thèse de l'université Paris Est. Disponible sur le site web de l'IGN :

http://recherche.ign.fr/labos/cogit/pdf/THESES/GAFFURI/these_gaffuri.pdf

[LECORDIX et AL 97] F. Lecordix, C. Plazanet and J.-Ph. Lagrange, 1997 : Platform for Research in Generalization (a) : Application to Caricature. GeoInformatica, 1997.

[Mackaness, Ruas, Sarjakoski] W. Mackaness, A. Ruas, and T. Sarjakoski, 2007: Generalisation of Geographic Information: Cartographic Modelling and Applications. Elsevier, Paris 2007.

[MUSTIERE 01] S. Mustière, 2001: Apprentissage supervisé pour la généralisation cartographique. Thèse de doctorat, Paris 2001.

http://recherche.ign.fr/labos/cogit/pdf/THESES/MUSTIERE/These_Mustiere_2001.pdf

[PLAZANET 96] C. Plazanet, 1996 : Enrichissement des bases de données géographiques: analyse de la géométrie des objets linéaires pour la généralisation cartographique (application aux routes). Thèse de l'université de Marne La Vallée, Laboratoire COGIT. Disponible sur le site web de l'IGN :

http://recherche.ign.fr/labos/cogit/pdf/THESES/PLAZANET/These_Plazanet_1996.zip

[REGNAULD 98] N. Regnauld, 1998 : Généralisation du bâti: structure spatiale de type graphe et représentation cartographique. Thèse de doctorat, Paris 1998.

[RUAS 99] A. Ruas, 1999 : Modèle de généralisation de données géographiques à base de contraintes et d'autonomie, thèse de Doctorat de l'Université de Marne-la-Vallée (France), spécialité : Informatique et Sciences de l'Information Géographique, laboratoire COGIT, IGN-SR 990009/S-THE, soutenue le 9 avril 1999.

[RUAS 02] A. Ruas, 2002 : Généralisation et représentation multiple. Hermès Lavoisier, Paris 2002.

[RUAS & LAGRANGE 92] A. Ruas et J.P. Lagrange, 1992 : ETAT DE L'ART EN GENERALISATION. Rapport interne, Institut Géographique National.